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CERTAIN EFFECTS IN THE HABITS OF SCHOOLING FISHES, AS BASED ON THE OBSERVATION OF *JENKINSIA*

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INTRODUCTION

The fact that *Jenkinsia stolifera* (Jordan and Gilbert) nearly always occurs in large, densely compacted schools is well known, and while this habit is typical of practically the entire family Clupeidæ, it is especially well marked in this particular species. Further, the permanent small size of the individuals and their tendency to keep in shallow water close to shore make them better suited to observation than most other clupeids. Such schools have been observed by numerous naturalists.

OBSERVATION

Dr. E. W. Gudger¹ records certain characteristics of their behavior as observed by him at the Tortugas Laboratory of the Carnegie Institution of Washington some years ago, without attempting an explanation of the phenomenon. Similar behavior was observed by the writer at the same place during the season of 1929. The present paper is devoted to an attempt to explain certain features of this behavior in purely mechanistic terms. The entire statement of Gudger follows, with its accompanying figure (Fig. 1).

These little fishes were found in great schools, numbering probably millions. They were especially abundant on the lee side of Loggerhead Key and around our wharf. They often hover over gray snappers, which seem to feed on them. However, the snappers either excite little fear in the herrings or else possess a great fascination for them. The little fish collect around them in dense swarms, resembling a swarm of bees, leaving a clear space immediately around the snapper about equal to his length, as shown in Plate I, figure 7. Whenever the snapper moves, the rather orderly swarm breaks up into a mob, which quickly rearranges itself when the big fish comes to rest. The little fish are in motion all the time, but the swarm remains fairly constant in size and shape.

This observation was fully confirmed by the writer at the old government wharf at Garden Key, and in addition it was noted that Gudger's "clear spaces" occurred under the conditions listed below.

¹1929. 'On the Morphology, Coloration and Behavior of Seventy Teleostean Fishes of Tortugas, Florida,' Carnegie Instit. Wash., Pub. 391, pp. 149-204.

1. Clear spaces occurred over any fish dark enough to show in contrast to the white sand forming the bottom.
2. Clear spaces occurred over any dark object sufficiently dark or near enough to the surface to be distinctly visible. These included rocks, large shells, pieces of iron pipe and other submerged objects.
3. Clear spaces occurred about piles and tie-rods of the wharf itself which emerged from the surface of the water.

In all cases, an identical distance was left about each object, irrespective of its size or shape. The shadow of objects entirely out of the water, such as the dock itself, had little, if any, effect on the formation of these schools (Fig. 2).

It was noted that this condition obtained when the water was crystal clear, and at such times inshore schools were observed to hover over only the white sandy bottoms. At other times, when the water was

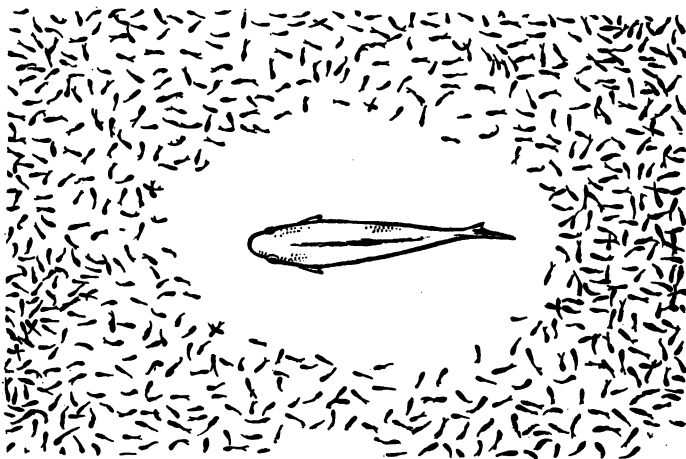


Fig. 1. "Showing swarm of *Jenkinsia stolifera* around and above the gray snapper, *Neomænis griseus*, but leaving a clear space immediately over the snapper." (After Gudger.)

The fishes are shown in an irregular arrangement in this drawing, whereas it is the nature of the fishes to arrange themselves in orderly files.

turbid, as after a storm, the schools were found to occur over any type of bottom, without discrimination. At night the schools disappeared, moving offshore, or more likely, simply dispersing, as some individuals could always be attracted to a submerged light.

INTERPRETATION

The interpretation of these reactions is made on a basis of experiments carried out at the New York Aquarium on various schooling

fishes by A. E. Parr.¹ In his paper it is demonstrated that the schooling of the pelagic fish (*Scombrus colias*) is controlled by a visual reaction. When two such fishes come within each other's visual range, they approach until just about far enough apart to avoid interference with each another, swimming from then on in a parallel fashion. If some disrupting influence turns the advance members of such a school back on itself, a "milling" is set up in which the school continues in a circular or elliptical path until some further disruption upsets it. This is clearly set

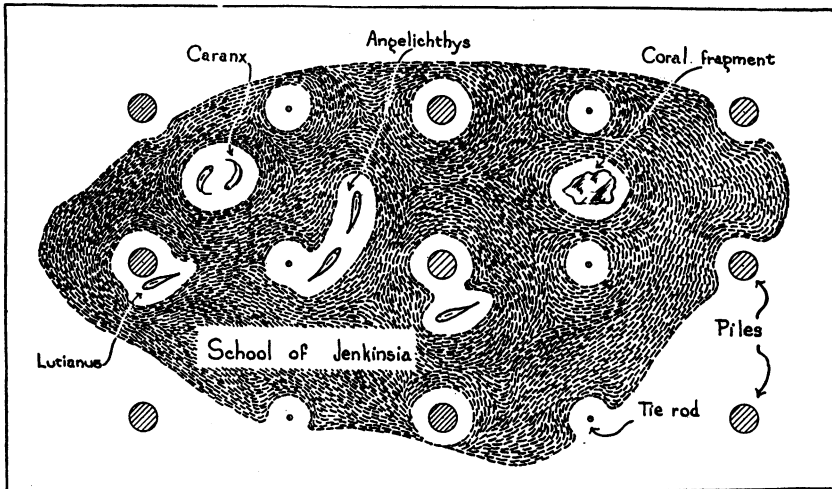


Fig. 2. Diagram of school of *Jenkinsia* based on observations made at the government dock at Garden Key.

Due to the numerous interfering objects, the school of necessity forms into "eddie" or "whorls" about each.

forth by Parr, and supported by good experimental evidence. *Jenkinsia* clearly shows schooling habits of this type, and owing to its habitat, such schools are constantly being deflected and consequently are usually "milling" about for the most part. These deflections are due mainly to shallowing water, rocks, piles, and the excursions of predatory fishes.

To this proposition of Parr we would add another to the effect that such fishes that depend on visual reactions for the formation of schools approach no closer to any other object than that at which it becomes clearly visible to them. It should be evident that this positive reaction to fishes of a similar size and a negative reaction to any other objects completely explains the conditions described by Gudger and here amplified.

¹1929. 'A Contribution to the Theoretical Analysis of the Schooling Behavior of Fishes,' Occ. Pap. Bingham Oceanographic Coll., No. 1, December, pp. 1-32.

This, of course, would give a measure of the visual ability of the species in question. Confirmatory to this is the fact that some object, such as a net handle, may be brought as close to the school as it habitually keeps from other objects without causing it to change its contour. Bringing it closer causes the school to re-form around it as about any other object. Such an experiment must be performed with great care and slowness, as a rapid movement causes an immediate scattering which is, of course, to be expected. The net handle moved rapidly at a much greater distance than the fishes approach a still object causes scattering. This is explained on the basis of the fact that an image moving across the retina is much more stimulating than a stationary one, i.e., it becomes "more" visible due to its movement. Doubtless differently colored objects would be approached to different distances dependent on their visibility. It so happened that all the objects noted were approximately of the same general tone. Experiments could be easily made to test the validity of this idea.

Young catfishes when still in schools, as Parr points out, remain only as far apart as their tactile barbels reach. This is also true of their approach to solid objects, as a glance in an early summer pond will demonstrate.

There is a temptation to try to reduce these two reactions to a single one, but it is not felt certain that this may be done successfully. We may tentatively assume that there is a tendency to maintain a certain retinal effect which is reached by approaching fishes of similar size at a given distance and other and darker objects at a greater distance. This would explain the two effects previously considered and also that of following larger fishes at a "respectful" distance. This may be prominently observed in schools of *Seriola* and *Naucrates* following much larger sharks. It is doubted, however, if such a viewpoint can be made to cover all the cases and it is simply set down as a suggestion. For the present it is probably better to consider the effect as the combination of a positive reaction to like individuals with a negative reaction to all other objects.

Larger predaceous fishes seem to take advantage of the "milling" of such fishes by swimming across an advancing front and turning it back on itself, after which the school remains more nearly stationary. Allen¹ describes such behavior in the case of *Alopias vulpes*. If this assumption is true it would appear that the excessively elongate caudal of *Alopias* functions efficiently in the rapid formation of a milling school. It would thus appear that this type of deflection would be much more

¹1923. 'Behavior of the Thresher Shark.' Science, N.S., LVIII, No. 1489, July 3, pp. 31-32.

efficient, in the light of Parr's work, than would be ordinarily supposed, reducing the tail action of *Alopias* and the milling of schooling fishes to two strictly bio-mechanical interacting reactions. Thus, it would be left unnecessary to assume a locomotor significance or a "maiming" value for the elongate tail, both of which seem to be questionable, while still this peculiar specialization would not be without function.

SUMMARY

1. *Jenkinsia* will not normally approach a dark, solid object closer than a certain distance, which is probably equal to its limit of visibility.

2. Schools of *Jenkinsia*, with their vacuities over and around solid objects, are interpreted in the mechanical terms of a positive mutual attraction of the fish for each other and a common negative reaction toward any other, generally dark, body.

3. It is possible that these effects might be reduced to different aspects of the same reaction.

4. Further study should throw light on the reactions of some pelagic fishes to larger objects in motion as well as the apparently "intelligent" rounding up by larger fishes of schools, reducing them to purely mechanical performances which would be, nevertheless, useful.

